AN AXIALLY DISPLACED EXPANDED INTERNALLY THREADED PANEL FASTENER FOR A HONEYCOMB PANEL STRUCTURE AND METHOD OF ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATION

[0001]

This application claims priority from Provisional Application Serial No. 60/439,512 filed on January 13, 2003, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

[0002]

The present invention is directed to a panel fastener assembly including an elastomeric sleeve and retainer assembly that can be inserted through a hole in a panel for receiving fasteners to secure the fastener to the panel and a support substrate.

2. Description of Related Art.

[0003]

In the field of aircraft and aerospace craft assembly, lightweight panels such as honeycomb panel structures are utilized and are mounted to bulkheads and aluminum intercostal ribs or beams that extend within the exterior housing of the aircraft structure.

[0004]

Various prior art methods of attaching honeycomb panels as floors or walls in aircraft manufacturing frequently requires the use of a female threaded clip nut which is separately attached to the aircraft structure. The clip nut can be formed of sheet metal steel to hold, for example, a hexagonical nut, and after the ribs or beams have been appropriately drilled for mounting holes, the clip nut can then be located so that a fastener will be inserted through a insert such as found, for example, in U.S. Patent No. 6,298,633 for securing a honeycomb panel to the support structure. A large number of such clip nuts and fasteners are utilized to provide sufficient locking force and fasteners such as a screw is then inserted through the hole and threaded through the clip nut to hold the panel. Problems, however, have occurred in the additional labor that is required in the insertion and alignment of the clip nuts with the corresponding holes in the support structure. As a practical matter, when a honeycomb panel is installed, some attachment points frequently are found not to have the clip nuts properly

installed and, for example, if the honeycomb structure is a floor board, it may have to be removed, new clip nuts installed, and then the floor board reinstated. The same problem can occur if the clip nut becomes stripped upon the insertion of the fastener.

[0005]

Another problem that can occur with the clip nut installation on aircraft structure is possible galvanic corrosion that can be caused by the clip nut scratching and interacting between the aircraft structure and inserts in the floor boards and walls. Since there is an iron-aluminum interface, corrosion can occur.

[0006]

Additionally, the clip nuts can cause the floor boards in the wall to be slightly raised off the appropriate attachment structure such as the intercostal ribs or beams. This problem further causes the walls and floor to resonate and can create unnecessary noise and vibration. Such vibration can again create scratching to permit a direct metal-to-metal contact to thereby provide corrosion.

[0007]

Additionally, misalignment problems are more prone to occur with use of the individual clip nuts.

[0008]

Accordingly, the prior art is still seeking to resolve these problems so that the panel structure can be securely held in an accurate and efficient manner while eliminating corrosion problems and high labor costs.

SUMMARY OF THE INVENTION

[0009]

An expanding panel fastener assembly for affixing a honeycomb panel structure to a support structure includes an insert member of a configuration for attaching through a hole that is bored or drilled through a honeycomb panel. Insert members of numerous different configurations can be utilized and as such, forms only one possible component in one form of the present invention. A flexible sleeve and retainer assembly has a configuration to extend through the installed insert member and the corresponding support structure whereby a portion of the assembly will be retained by the insert member. The flexible sleeve and retainer assembly includes a moldable flexible sleeve, an expander member and a retainer member. A fastener member of a configuration that extends through the flexible sleeve when installed in the panel and further through the support structure and thereby operatively

engages the retainer member such as a nut member is utilized to complete the assembly. Tightening of the fastener member such as a screw relative to the nut member will expand the expander member below the support structure to thereby prevent withdrawal of the nut member. Additionally, this flexible sleeve is also compressed and expanded so that it can further provide a sealing configuration with the support structure. Since the flexible sleeve is relatively movable, misalignment problems can be addressed within certain tolerances, and issues of vibration and corrosion can be significantly reduced.

[0010]

An operation and method of fastening an aircraft panel structure to a support structure in an aircraft can comprise the steps of providing openings in the panel structure such as a honeycomb structure by appropriately drilling or reaming holes at predetermined locations. Insert members can then be inserted through the panel openings usually with a flange on one side and a bending of a lip configuration on the other side to thereby establish a structurally strong opening in, for example, a honeycomb panel. A large number of such openings in a honeycomb panel can be utilized to provide a sufficient attachment force to the support structure such as intercostal ribs or beams in an aircraft. A flexible sleeve and retainer assembly may be inserted through each of the insert members in the panel structure. The panel is then aligned with a support structure having complementary openings for receiving the flexible sleeve and retainer assemblies.

[0011]

Finally, fastener members such as screws can be inserted through the panel within the flexible sleeve that also extends through the support structure opening. The fastener member can then engage the retainer member such as a nut, and as the nut is tightened, the fastener member will expand an expander member, thereby preventing the nut member from being pulled through the opening in the support structure.

[0012]

The operative engagement of the fastener member with the retainer member such as a nut can further compress the flexible sleeve which can be formed from rubber or a silicone material to thereby further seal against the support structure and help reduce any vibration and corrosion issues.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

The objects and features of the present invention, which are believed to be novel, are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages, may best be understood by reference to the following description, taken in connection with the accompanying drawings.

[0014]

Figure 1 is an exploded view of a panel, fastener assemblies and intercostal support ribs of an aircraft floor.

[0015]

Figure 2 is a cross-sectional disclosure of the insertion of an insert member in a honeycomb panel.

[0016]

Figure 3 is a partial cross-sectional perspective view of the relationship between the honeycomb panel, insert member and the flexible sleeve and retainer assembly.

[0017]

Figure 4 is a cross-sectional view of a fastener member entering a panel and support structure through the flexible sleeve.

[0018]

Figure 5 is a cross-sectional view showing the fastener member engaged and torqued to the appropriate pressure.

[0019]

Figure 6 is an exploded view of the panel fastening system panel and support structure.

[0020]

Figure 7 is a top view of one portion of the expanding member.

[0021]

Figure 8 is a top plan view of another portion of the expanding member integral with a nut member.

[0022]

Figure 9 is a top plan view of an alternative expanding member; and

[0023]

Figure 10 is a perspective view of the expanding member of Figure 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024]

Reference will now be made in detail to the preferred embodiments of the invention which set forth the best modes contemplated to carry out the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be obvious to one of ordinary skill in the art that the present invention may be practiced without these specific details. In other instances, well known methods, procedures, and components have not been described in detail as not to unnecessarily obscure aspects of the present invention.

[0025]

Features of the present invention overcome the following design issues:

1. The new fastener / insert needs to develop the same load carrying characteristics as the existing insert clip-nut combination.
2. The new fastener / insert needs to work as a replacement part as well as a new aircraft assembly.
3. The new fastener / insert needs to have a positive secondary locking device (fail safe).
4. The new fastener / insert must work within the original installation hole and length requirement.
5. The new locking device needs to reduce or eliminate galvanic corrosion.

[0026]

The installation of this fastener assembly gives the user many advantages over prior art systems currently in use. The advantages of using this system are, but not limited to:

Labor reduction at assembly and maintenance cycles.

Elimination of an expensive component (clip nuts).

A fastener that is rebuildable from the topside surface of panel.

A fastener that may reduce or eliminate galvanic corrosion.

A fastener that reduces noise levels in aircraft interior.

[0027]

Floors and walls having this fastener can easily be removed and reinstalled. If the fastener sub-component should become unusable, the sub-assembly can be removed and replaced without removal of floors or walls.

[0028]

The clip nuts currently in use are the primary cause for initiation and propagation of corrosion. The initial installation of the clip nut scratches the anodized and primed surface of the aircraft structure and exposes bare aluminum to the elements and thus starts corrosion. Use of this new fastener assembly eliminates that source of corrosion plus the elastomeric material in the assembly helps to isolate the fastener from the aircraft structure and provides a secondary advantage which is noise isolation.

[0029]

A housing insert 6 is permanently bonded to a honeycomb sandwich panel 2. The housing insert 6 can support a working assembly and related components. The flexible sleeve and retainer assembly 12 is molded from elastomeric compounds, such as rubber or silicone material, for example, to meet a Boeing Specification BMS-83 for rubber. The assembly contains an upper insert portion 32 that creates thread-locking to meet the requirements of NASM-25027 – Nut Self-Locking specification. The upper insert 32 is molded permanently in the elastomeric compound. The next sub-assembly components are a threaded nut segment 36 and a lower follower segment 38. These final two (2) components are also molded permanently into the elastomeric compound.

[0030]

The insert housing 6 can have a flange 20 of 0.875 inches in diameter having a thickness of 0.02 inches. The body length is varied and dependent on panel thickness. Another external feature can be a radial groove having two tapers on each side that is located mid body and has a reduced diameter of about 30 percent of the body diameter that is used to reduce weight. An optional feature on the exterior of the part is a knurled portion or irregular surface 24 next to the flange 20 that is used to retain the insert 6 after installation, for the purpose of allowing the adhesive to cure. The upper internal feature is a tapered and reduced cross sectional rim 22 with a controlled counter bore depth designed to adjust for panel and

skin thickness variations; this area will become the flared area after installation. The other internal feature is a controlled countersink diameter that controls screw height after installation.

[0031]

The internal bore is modified to accept the upper portion of the elastomeric or flexible sleeve and retainer assembly 12 and the through hole will be modified to allow the retainer assembly 12 (described below) to have radial float as to compensate for any panel hole misalignment.

[0032]

The preferred material for the housing for the purpose of this description will be aluminum but is not limited to that material.

[0033]

The upper insert portion 32 of the retainer assembly 12 will be manufactured preferably from stainless steel but is not limited to this material selection. The upper insert portion 32 can be tapered on the outside diameter to match the internal taper on the housing. The outside diameter will also have a radial groove to reduce weight and increase the surface area to allow better elastomer bonding. This upper insert portion engages the major diameter of the installation screw thread to provide locking torque per NASM-25027 requirements. The end of the insert portion facing upward will have a countersink to match the flat head configuration of the installation screw, flat head design, but is not limited to that single shape screw. The lower end of the insert portion will have a counter bore that will be used to connect and increase the tensional resistance of the elastomeric portion to be attached later in the assembly process containing the two lower segments.

[0034]

Two lower components make up a lower assembly (1 nut segment and 1 follower segment). A distinguishing feature that further separates this nut and follower from a standard nut and follower design is that the centerlines of each component are 0.03 inches offset in opposite directions to each other as assembled so that when a fastener 14 is inserted, the components will expand to lock against any removal force.

[0035]

The material is stainless steel but is not limited to that material. The dimensions of the nut segment are the same as the follower .100 thick and .03 inches offset, the thread is 10-32 UNJ-3B for a standard installation screw for this size; there is no truncation. An

additional feature of the nut segment is an arm of material protruding in the opposite direction of the offset with a height that matches the follower segment thickness and fills in the truncated part of the follower segment. This extra piece of material allows the nut and expanding follower to contact the bottom surface of the structure and keeps the assembly from tilting, thus allowing the installed fastener assembly to resist pull out.

[0036]

The follower segment material is also stainless steel but not limited to that material. The dimensions are .100 thick with a .030 offset through hole. The segment is truncated in the direction of the offset; this allows one side of the segment to be displaced radially outward when the installation screw is engaged.

[0037]

The following is one method to assemble the sub-assembly components of this invention.

[0038]

After completing the machining and plating processes, the three (3) components are assembled into a die for elastomeric molding. The mold creates a tapered portion of elastomeric material around the upper segment. As part of the upper segment component, the mold creates a section of elastomeric material plug on the lower part of the segment that fills the counter bore. This portion of elastomeric material does two (2) things: first it starts the long section that will contain the two (2) follower elements and creates a larger bonding surface. Second as a stiffener it also increases the torsional stiffness of the lower sub-assembly during final assembly. In this and any other embodiment of this invention, one can include an armature of fibers or reinforcing mesh to aid the stiffness and durability of the elastomeric material. This completes the assembly of the sub-assembly.

[0039]

Preparation of the honeycomb panel 2 consists of drilling an installation hole 8. Most installation holes 8 are controlled in this process. For the purpose of this disclosure the installation hole is 0.455 inches in diameter. The installation hole diameter is a function of a selected size of fastener and panel and is not to be limited to 0.455 inches diameter. The housing portion of the assembly is bonded to the bottom outside skin of the honeycomb sandwich panel 2 with the use of adhesive. The type of adhesive used for bonding is controlled by the end user of the fastener, but for the purpose of this disclosure it can be Epi-Bond 420 but not limited to that selection.

[0040]

Adhesive is applied to the top side of the flange 20 of the housing insert 6 or to the honeycomb panel surface 18 around the installation hole. Install the panel fastener housing insert 6 into the installation hole 8 up to the panel retention feature (knurl) 24. Press down on the back of the insert flange until the flange pops in and bottoms out against the panel skin. Using an installation-flaring tool 26, put the pilot into the through hole until the tool stops against the top of the housing insert 6. Using a press or a device that will create a compression load, press down until the installation tool stops against the top of the panel. The housing insert 6 is now fully installed. Curing of the adhesive should be carried out according to adhesive manufacturer's instructions.

[0041]

The final part of the assembly is to put the assembled honeycomb sandwich panel into the aircraft. After the preliminary location of the panel is found, put the flexible sleeve and retainer assembly 12 into the housing inserts 6. Acquire the appropriate assembly screw 14 and install through the upper insert portion until resistance is felt through the screw. Start turning the screw clockwise until the final assembly torque is reached. During the torquing sequence the lower assembly elements are drawn up against the support structure. As the lower assembly is drawn up by the screw action, the external surfaces of the elastomeric material 34 expand radially outward, creating a positive seal between the panel fastener and the aircraft structure. This positive seal provides pull out strength (fail safe), and noise and vibration dampening.

[0042]

Removal of the honeycomb sandwich panel 2 is accomplished by removing the installation screws and separating the panel from the structure. The elastomeric sub-assembly of the panel fastener may be left inside the housing or easily removed and replaced with a new sub-assembly.

[0043]

As can be seen in Figure 1, the intercostal ribs or beams 4 can, for example, be a U- or C-shaped aluminum beam 4 with appropriate holes 10 that are predrilled at desired locations. Corresponding holes 8 are provided within the panel insert 2 which, for example, as shown, can be a honeycomb structure as known in this field. A large number of different housing inserts 6 can be preinstalled in the panel insert 2. The procedure for such installation is shown, for example, in Figure 2 where a flange 20 of the insert housing 6 can be

adhesively applied to a lower panel surface 18. When placed on a support surface, a compression tool 26 can then be applied to spread the upper rim 22 locking the insert housing 6 within the panel housing. The upper panel surface 16 can be compressed downward to insure an upper flat surface. At the base of the body of the insert housing 6 adjacent the flange 20, a knurled section can help align and fasten the insert housing 6 during the installation procedure. This can be seen in Figure 3 of our present drawings. Additionally, the flange 20 can optionally have weight reducing holes 30 if desired.

[0044]

With the completion of the attachment of the insert housing 10 to the panel 2, the panel assembly is now ready to receive the flexible sleeve and retainer assembly 12 which can have a conical upper surface for interfacing with the interior diameter of the housing insert 6. As can be appreciated, various configurations and designs are possible within the parameters of the present invention since the prime purposes is to preassemble retainer assemblies 12 prior to aligning the panel assembly 2 with the aircraft support structure 4 as shown in Figure 4. As can be seen, the flexible sleeve and retainer assembly 12 is of a length to adequately extend through the hollow insert housing 6 and the hole 10 within the U-beam 4. The molded rubber sleeve 34 captures a sleeve spacer 32, and in the embodiment of Figure 4, a lower retainer member such as a nut 36 having an integral expander portion 40. Also molded within the tubing rubber sleeve 34 is a complementary expander member 38 that is not directly affixed to the retainer nut 36.

[0045]

As shown in Figure 5, when the fastener such as an elongated screw 14 extends through the expander member 38, it displaces this component radially outward to thereby prevent retraction of the nut 36 back through the hole 10 in the beam 4.

[0046]

It should be appreciated that other configurations of expanding members can be utilized such as the split ring expander 42 shown in Figure 9 and Figure 10. In this alternative arrangement, the nut or retainer member 36 can be of a conventional configuration and is separate from the split ring expander 42. The split ring expander 42 has a thickness in dimension that again will prevent removal of the nut through the opening 10 in the support beam 4. To accommodate this expansion, an axial pivoting rib groove 44 can be positioned across from an opening in the split ring expander 42. As shown in Figures 9 and 10, split ring expander 42 is also embedded within the rubber sheath or tubular sleeve 34.

[0047]

Referring again to Figure 5, as the expander member 38 prevents withdrawal of the nut 36 from the undersurface of the support beam 4, the rubber sleeve 34 can be crimped to provide a seal against the undersurface of the beam 4. This helps prevent any corrosion effect and also can act as a vibration damper.

[0048]

Referring to Figures 6 through 8, an exploded view of the assembly including the first embodiment of the expander member 38 is shown. As can be seen, the center of the expander member 38 is offset from the center of the nut 36 so that it is displaced radially outward when the fastener 14 is inserted. As can be appreciated, however, this is a schematic view in Figure 6 since the rubber sleeve 34 is molded about the sleeve spacer 32, retainer nut 36 and the expander member 38.

[0049]

In summary, the present invention describes both an axially displaced expanded internally threaded panel fastener for a honeycomb structure and a method of assembly. As can be readily appreciated, this structure utilizes an elastomeric sleeve and nut assembly that provides a number of improvements against vibration, corrosion and misalignment, and such a structure could be used independently with a panel or, as shown in the preferred embodiment, for attaching to a substructure in the aircraft.

[0050]

Although the present invention has been fully described in connection with the preferred embodiment thereof, it is to be noted that various changes and modifications apparent to those skilled in the art are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

[0051]

Those skilled in the art will appreciate that various adaptations and modifications of the just-described preferred embodiment can be configured without departing from the scope and spirit of the invention. Therefore, it is to be understood that, within the scope of the amended claims, the invention may be practiced other than as specifically described herein.